CENTRAL HEATING PLANT MODERNIZATION

Dennis Vevang, CECPW-EM, (703) 806-6071

EXECUTIVE SUMMARY

The Assistant Chief of Staff for Installation Management (ACSIM) is funding a $300 million, 5-year program beginning in FY 1998 to repair with operation and maintenance account (OMA) dollars failing central heating plants and distribution systems. The purpose of this program is to modernize old and failing central heating plant equipment and distribution systems in such a way that the modernized plants and distribution systems will provide the installations with reliable, safe, energy efficient and environmentally friendly service.

INTRODUCTION

The Army has a large utility infrastructure, approximately $15 billion in plant replacement value (PRV), that is in fair to poor condition. Current maintenance and repair funding levels for utility plants are inadequate at 1 percent of PRV. The Army strategy is to privatize utilities to the maximum extent possible. By privatizing, installations will better meet mandated manpower reductions while improving the quality of utilities. When utilities cannot be privatized, they need to be modernized. Army strategy is to focus utilities modernization on the $1.2 billion worth of central heating plants and distribution systems that are least likely to be privatized. The modernization of heating systems also saves OMA dollars because of more efficient equipment, reduced fuel requirements, eliminated steam and hot water leaks, and reduced manpower requirements.

The Army has programmed $60 million per year from FY 1998 through FY 2002 for Central Heating Plant Modernization in POM98-03. Criteria used to prioritize modernization is the Installation Status Report (ISR); cost of operation in dollars per million kilojoules (British thermal units), maintenance and repair; engineering analysis; saving-to-investment ratio (SIR); and the lack of opportunity to privatize.

A preliminary list of projects for heating plant modernization has been developed for about two dozen installations. Installations eligible for the Central Heating Plant

Modernization in Fiscal Year 1998 are Forts Meade, Jackson, Lewis, Benning, Belvoir, Drum, and Aberdeen Proving Ground. Fiscal Year 1999 Forts Jackson, Eustis, Campbell, Carson, Benning and Wainwright are scheduled. Fiscal Year 2000 covers Forts Carson, Leonard Wood, Belvoir, Wainright; Aberdeen Proving Ground and Redstone Arsenal. Fiscal Year 2001 has scheduled for the program Forts Stewart, Gordon, Riley, McNair; and Redstone Arsenal. The final year (Fiscal Year 2002) has in the program Forts Gordon, Rucker, Lee, Dix, Hood, Myer; and Carlisle Barracks.

During this 5 year period, projects at these Army installations will be assessed by a validation team from ACSIM, the U.S. Army Center for Public Works (USACPW), the U.S. Army Corps of Engineers Construction Engineering Research Laboratory (USACERL), the U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory (USACRREL), the local Corps of Engineers District, and the Major Command (MACOM). The purpose of these site visits is to assist installations in project development and also to validate the project.

BACKGROUND

Many of the central heating plants are 30 to 40 years old and are nearing the end of their design life. These plants experience poor energy performance and reliability. When it is time to replace the plant, either the same type of system is used or the design team may give up on central heating plant and replace it with individual boilers in each building. These solutions may or may not be the best. The following identifies methods and guidelines to evaluate heating plant options and select the most efficient, cost-effective heating supply.

CONDITION ASSESSMENT

The first step is to assess the condition of the central heating plant and distribution system or the individual heating systems. The Installation Status Report (ISR) is used to assess the conditions of systems and subsystems. The ratings are red for poor, yellow for some deficiencies , and green for good. The individual systems and subsystems ratings are rolled into a single rating or C1 for excellent, C2 for satisfactory, C3 for poor, and C4 for failed or failing. The ISR ratings were used in selecting the projects for the Central Heating Plant Modernization Program. Since the ISR is an important tool for Army planners, the installation should have current ISR ratings for their heating plants and distribution systems.

Another useful assessment tool is the Status Quo program. This program can provide estimates of the useful life of boiler plant equipment and the approximated cost of most systems, including ancillary equipment. The Status Quo program is one component of a series of programs being developed by the USACERL to evaluate conversion alternatives. Status Quo is a microcomputer program that estimates the life cycle costs of maintaining an existing energy plant in its present condition, thereby providing a baseline for comparing the life cycle costs of alternatives to status quo: modernization, retrofit, or construction of a new plant. USACERL Technical Report FE-95/13 entitled THE CENTRAL HEATING PLANT STATUS QUO PROGRAM and dated March 1995 explains the Status Quo program.

Boiler inspection is also important to assess the condition of the heating plants. As per AR 420-49, all high pressure steam boilers with pressures above 103 kilopascals (kPa)(15 pounds per square inch gage or psig) and all high pressure/temperature water boilers with temperatures above 120 degrees C (250 degrees F) in active use shall be inspected. Inspections shall be made per the rules for Inspections, Section VII, Care of Power Boilers, American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code. Generally, boilers shall be inspected semiannually. The primary inspection will be both internal and external and the secondary inspection will be external under steam pressure.

Some MACOMs fund their own high pressure boiler inspection program. Other installations can issue their own contract. Also, USACPW has high pressure boiler inspection contract. Installations can issue delivery orders through their local contracting office against the USACPW contract, by sending the funds to USACPW. This contract now covers boiler inspections (internal, external, etc.); ASME stamped unfired pressure vessel inspections (limited to vessels located in boiler plants, includes air receiver tanks and deaerators); and evaluation services to include integrity studies and failure analysis.

Distribution systems also need inspection, especially the buried, underground system. USACERL Technical Report entitled M-91/01 MODERNIZATION OF EXISTING UNDERGROUND HEAT DISTRIBUTION SYSTEMS and dated MARCH 1991 covers maintenances of underground distribution system manholes and is a useful document in preventive maintenance of these systems and assessing the distribution system’s condition.

DESIGN ALTERNATIVES

Several different designs can be selected. These include: steam versus high temperature hot water versus low temperature hot water; central heating plant versus individual heating units for each building; and aboveground, shallow concrete trench, or buried distribution systems. However, it is important to understand the advantages and problems with these different designs.

Lessons Learned on Heat Distribution Systems

Why is heat distribution important? Army has about 5,150 kilometers (3,200 miles) of heat distribution lines. At $1,000 per meter ($300 per foot), the replacement cost is $5.1 billion. Excess heat loss in heat distribution lines located on Army installations in the continental United States is about $30 million/year. Boiling manhole can cost between $50,000 to $125,000 per year in lost energy.

The Federal Agency Committee (FAC) on Underground Heat Distribution Systems was formed in the 1970's to study distribution systems. The FAC had representatives from the Army, Air Force, Navy and Department of Veterans Affairs. The FAC goals were reliable heating and cooling exterior distribution systems; systems achieve long life; and research and development activity. The procedure was for the FAC to preapprove conduit type underground heat distribution systems. The manufacturer followed test protocols and, if passed, they were awarded a letter of acceptability which is included in their product brochure. The FAC is not now active.

Problems with underground distribution systems prompted a USACERL study. Thirty-five systems on 15 installations were studied in 1993. The findings were that drainable, dryable, air pressure testable (DDT) type of underground heating distribution systems with fiberglass casing failed more than 90% of the air pressure tests. This air pressure test is performed by pressurizing the conduit with 103 kPa (15 psi) of pressure and seeing if the conduit will hold the pressure. The USACERL study also found that many systems were not installed correctly. For example, steam and condensate were installed in the same conduit; this is not acceptable although high temperature hot water supply and return may be in same conduit. Other findings were conduit drain plugs were missing; steel drain plugs used instead of brass drain plugs; manholes that were spaced more than 150 meters (500 feet) apart; slope of distribution was not steeper than 42 millimeters per 10 meters (1 inch per 20 feet); manholes were too small to work in; conduit vents were sometimes plugged; certificate of compliance by contractor not provided. The certificate of compliance is a notarized statement signed by officers of both the manufacturing firm and the contractor firm that the system has been installed according to the contract and the approved product brochure. Many times the supplier representative's field reports could not be located. It is the responsibility of the representative to observe unloading of material and inspect the material; inspect trench before laying of conduit; inspect thrust blocks and cold springing of conduit; conduit air test; and backfill of trench.

In addition to the USACERL study, long running distribution studies have been conducted at Fort Bragg, N.C.; Fort Jackson, SC; and Fort Riley, KS. At Fort Bragg the distribution system has been studied since 1983. The goals of the study are condition assessment of manholes and manhole internals and determine impact on system life expectancy; collect maintenance and operation information to provide design and material requirements; and prepare recommendations for corrective actions on each manhole to increase distribution system's life.

The study at Fort Jackson, SC, consisted of 3 phases. Phase I installed 4,100 meters (13,500 feet) of direct buried conduit and 1,100 meters (3,500 feet) of shallow concrete trench. This was completed in August 1986. Phase II installed 2,000 meters (6,500 feet) of direct buried conduit and 3,200 meters (10,500 feet) of shallow concrete trench. This was completed in January 1988. Phase III installed 3,350 meters (11,000 feet) of fiber-glass reinforced plastic (FRP) conduit and was completed in February 1987. Additional direct buried systems and a shallow trench system also were inspected for additional information.

The study at Fort Riley installed in 1984 1,500 meters (5,000 feet) of direct buried conduit (Perma-Pipe) in Custer Hill Area and 1,500 meters (5,000 feet) of concrete trench with the trench tops at grade level.

Results of these studies at these 3 Army installations show that direct buried FRP conduit systems do not last 25 years; shallow trench systems perform very well; the new design raised top manhole with screened side panels and hinged aluminum covers performs very well for both shallow trench and direct buried conduit systems; direct buried steel conduit systems with new manhole design performs very well.

For wall penetrations, caulking compounds are not good; need metal sleeve with water stop at the manhole wall penetration with a link seal between the sleeve and the conduit casing; material of link seal should be rated for operating temperature. Zinc-rich coating on end plate is excellent. Water jet type sump pumps are unreliable. Platform mounted electric sump pumps are generally unreliable unless sump pump is used with new design raised top manhole. Field welds to connect carrier pipes are major cause of failure. Construction criteria has been revised to require 100% weld inspection.

As a result of the survey and on-going distribution studies, the following policy was adopted in October 1994 for Heat Distribution Systems (HDS). For Army Heat Distribution Systems with carrier pipe temperatures of 95 degrees C (200 degrees F) and above:

ALL SITES:

Heat Distribution systems for all sites will be selected in the following order of preference.

a. Aboveground
b. Shallow Concrete Trench
c. Direct Buried

Direct Buried systems shall only be provided where aesthetics or functional requirements preclude the use of aboveground or shallow concrete trench systems. Direct Buried systems shall use fixed end seals only. Gland type end seals will not be permitted. Direct Buried systems, when used, shall be provided in accordance with Corps of Engineers Guide Specification (CEGS) 02695 and the following criteria. CECG 02695 gives the Site Classification definitions. These classification are base on where the water table is expected to be in relationship to the underground systems and also how much surface water is expected to accumulate and remain in the soil surrounding the underground systems.

BURIED CLASS A SITES:

Where a direct buried system is required, only class A drainable, dryable, air pressure testable (DDT) systems with steel casings will be used.

BURIED CLASS B SITES:

Where a direct buried system is to be provided, only class A DDT systems with steel casings or class B water spread limiting systems will be used.

BURIED CLASS C AND D SITES:

Where a direct buried system is to be provided, only class A DDT systems with steel casings, class B or class C water spread limiting systems will be used.

Technical Manual TM 5-810-17, HEATING AND COOLING DISTRIBUTION SYSTEMS, May 1994, provides criteria and guidance for the design and construction of heating and cooling distribution systems. This technical manual also gives the design details of the raised top manholes. This manual says that in most circumstances, experience has shown that aboveground systems are the most life cycle cost effective. Experience has also shown that the maintenance and repair costs of shallow concrete trench systems are lower than for direct buried systems, and they must be included in the life cycle cost analysis.

To comply with latest Federal Acquisition Regulations (FAR) requirements and to eliminate the use of prequalification requirements for the high temperature prefabricated underground heat distribution systems, a new guide specification was prepared in 1997 by the mechanical center of expertise in the Mobile District. The new specification is Corps of Engineers Guide Specification 02695 PRE-ENGINEERED UNDERGROUND HEAT DISTRIBUTION SYSTEMS. It includes material and performance requirements based on existing Class A systems with steel casings and the existing Class B and Class C systems.

DESIGN CONSIDERATIONS

The following should be considered when selecting whether to use steam or hot water distribution systems and central versus individual units. Steam distribution has an advantage over hot water distributions because steam requires less pumping power. Steam is also necessary for some industrial processes and is well suited for many munitions processes needing heating without flames or combustion. However, steam systems have much greater makeup rate than hot water systems and require more maintenance because of steam trap replacement. Hot water systems have large thermal inertia with the large volume of water between the central heating plant and the user acting like a heat reservoir. Hot water systems may require larger pipe sizes than steam depending upon the temperature drop selected.

Above ground distribution systems have the lowest first cost and lowest maintenance costs of any distribution system. However, many installations do not want these systems because they consider them a visual nuisance. These above ground systems can be successfully integrated into the installation’s landscaping plan. The concrete shallow trench provides easy access for maintenance and repair by removing the concret tops. These exposed tops may be used as sidewalks if the system is installed at grade. These shallow concrete trenches should not be routed through existing flood plains or in areas where seasonal water accumulates.

For central heating plant versus individual heating units in each building, consider the thermal load and area. For an area to be favorable for district heating systems, the thermal load density, which is the ratio of the peak diversified heating load (in MBtu/hr) divided by the area (in acres), should be above 0.7. Another consideration for central versus individual system is the more maintenance and personnel requirements for servicing the individual heating system units.

CONCLUSION

With the Central Heating Plant Modernization Program and the coordination between the installations, ACSIM, the local Corps of Engineers District, MACOMs and the USACPW and with the expertise in central heating plants provided by USACERL and USACRREL, much that has been learn about distribution systems can be incorporated into the modernized project. Modernized heating systems will result in more reliable, state of the art equipment which will increase mission readiness, minimize pollutants, save OMA dollars, and increase quality of life.